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ADAMANT

*BSA Centreless Grinder No 4**

This centreless grinding machine, as shown at the Hanover Fair, 1957, is equipped for grinding an armature shaft component on four stepped diameters. The tolerance required is 0.0003 inch, removing 0.005 to 0.006 inch of stock in two cuts, with a production rate of 450 operations per hour at 100% efficiency.

The production cycle is completely automatic, the components being ground by the infeed method. The infeed attachment is arranged to run continuously during production so that one revolution of the infeed cam represents the full cycle time for producing each component.

The workpieces are fed from a vertical type magazine into an automatic synchronized loading attachment which is controlled to operate at the correct moment in the cycle by a pilot air valve operated from a cam on the infeed attachment. This valve initiates the return of the overhead carriage which at the conclusion of the grinding operation conveys the component from the wheel area on to a size gauging block positioned on a cross-slide, and at the same time the previously ground component is ejected from the gauge block into the delivery tray provided. The cross-slide then advances to the loading position with a new component from the magazine, and the overhead carriage conveys this workpiece to the grinding position between the wheel. The cross-slide returns during the grinding operation to accept the next component from the magazine.

The machine is also fitted with automatic sizing and grinding wheel head feed compensation; by this system each component, after grinding, is automatically sized and any growth towards the upper limit of the tolerance band is registered in the Sigmatrol unit. The grinding wheel head will then automatically advance and bring the component size towards the lower limit of the tolerance band. This means that the

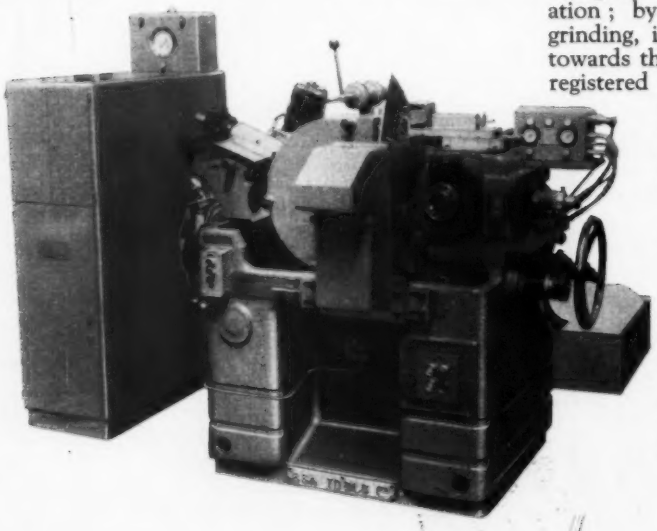

Fig 1. A general view of the BSA No 4 Centreless Grinder with fully automatic set-up comprising magazine loading attachment, synchronized with automatic infeed. The illustration also shows the automatic sizing, wheel head compensation and grinding wheel dressing.

* *BSA Tools Group Journal* 1957 Vol 3 (7) pp 2-3 (July-Sep).

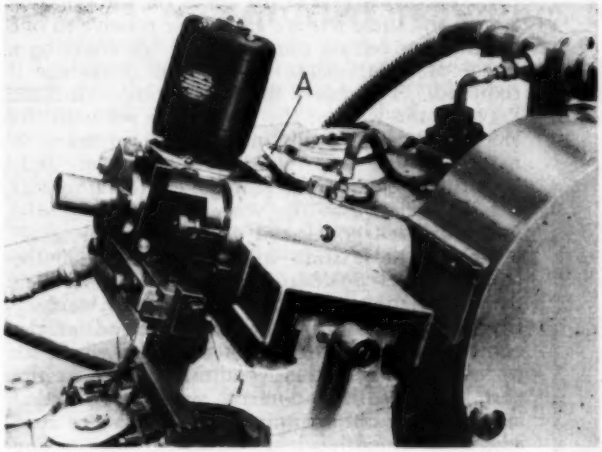

Fig 2. Mechanism for automatic advance of diamond quill at each end of the truing stroke. A is automatic wheel head compensation unit.

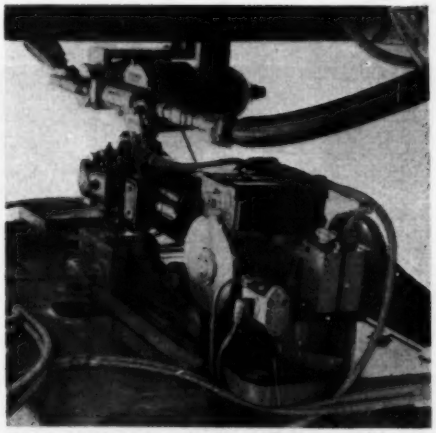

Fig 3. Automatic infeed attachment working on a continuous cycle.

machine is automatically controlled for continuous production of workpieces within the allowable tolerance. The actual sizing of the ground piece on the gauging block positioned on the cross-slide takes place during the spark-out period of the grinding operation. The sizing period is determined by a switch operated from a cam mounted on the infeed cam spindle. If for any reason components are produced which fall below the lower limit of the tolerance, a minus alarm signal is given and the machine cycle is arrested.

Additionally, provision is made for automatic wheel truing, and in order to provide for the periodic initiation of the truing cycle, a predetermined counter device is fitted which can be pre-set to a determined number of pieces. This means that after grinding the nth piece the wheel truing cycle introduces the following operations:

(1) the infeed motor is arrested with the assistance of a magnetic brake;

(2) the grinding wheel two-speed power truing motor commences its first pass across the grinding wheel on coarse feed.

Sizing is arranged to take place during the spark-out period of the grinding, so that upon sizing the nth piece prior to automatic wheel truing, the infeed motor is arrested immediately, before the operation of the pilot air valve controlling the return of the overhead loading carriage, and with the infeed cam holding the wheel head in the forward position. By arresting the infeed cycle at this point, the grinding wheel is in the advanced position ready for grinding wheel head compensation after truing. The two-speed power truing attachment traverses the grinding wheel once on 'coarse' feed and returns on 'fine' feed. At each end of its stroke the diamond quill is arranged to advance the diamond a predetermined amount automatically. On reaching the end of the return stroke of the truing slide, the grinding wheel head automatically advances until the correct position is reached for producing the next component to within the tolerance required. When this position is reached, the infeed attachment motor restarts and also re-introduces the loading operation.

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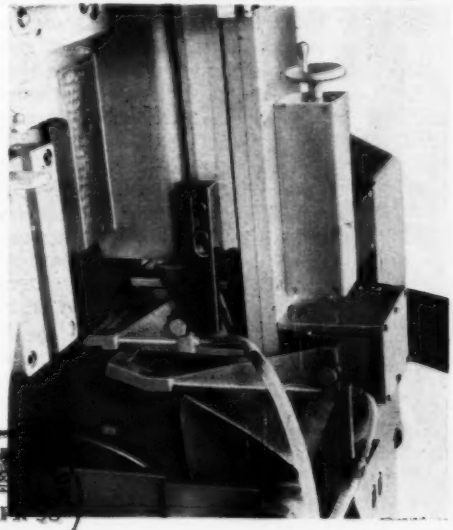
Fig 4. Adjustable jet assembly which controls the automatic wheel positioning after dressing.



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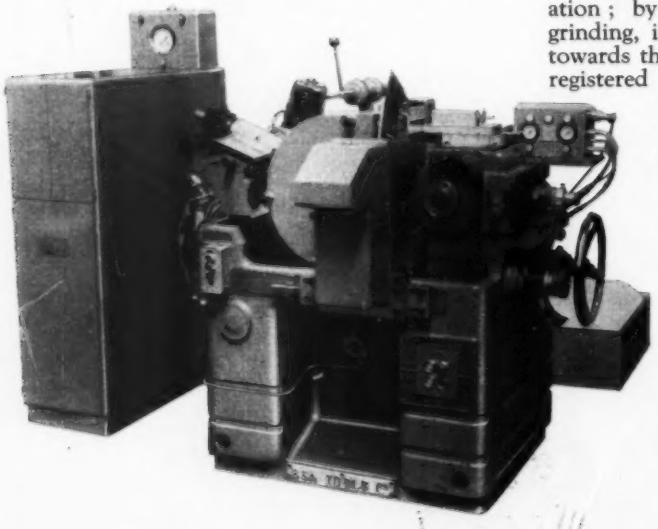

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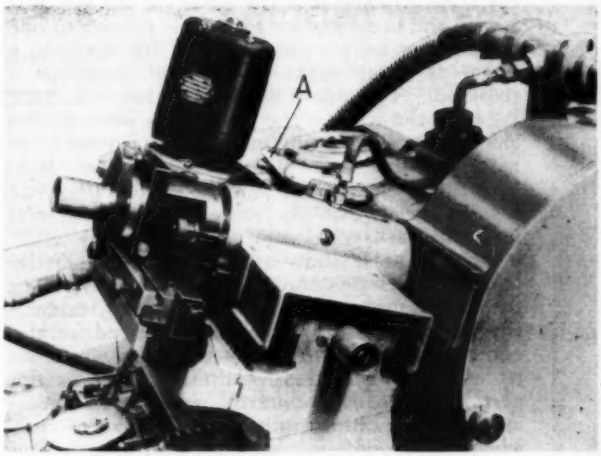

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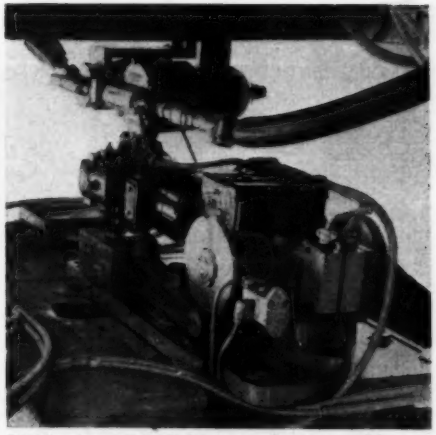

Fig 3. Automatic infeed attachment working on a continuous cycle.

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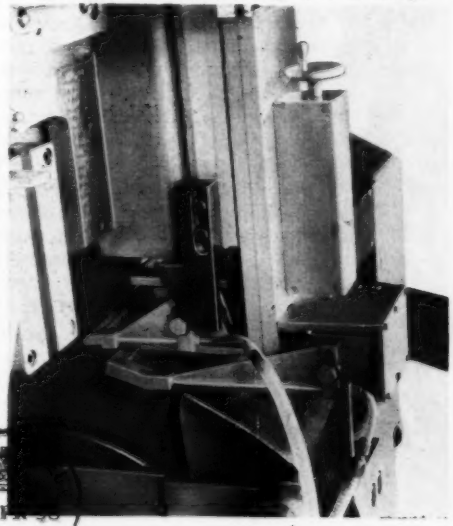

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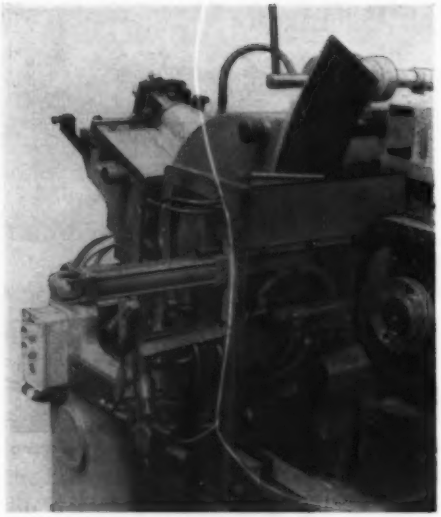

Fig 5. Automatic synchronized loading attachment showing overhead carriage for transferring workpiece from cross slide to wheels.

At the same time the predetermined counter device automatically resets to zero.

The positioning of the grinding wheel head after truing is controlled by the position of a pair of sensing jets mounted on a compound slide arrangement and located between the grinding and control wheels. One jet senses position off the control wheel and the other off the grinding wheel, and these jets are adjustable relative to one another for setting purposes and for covering a range of components of varying diameters if required. To achieve the correct throat distance between the wheels, the position is set with the aid of a master component and adjustment is made to the top slide. The bottom slide adjustment enables the pair of jets to be moved together relative to the wheels. A pair of dial indicators are positioned on the control wheel head, and these show a zero reading when the correct wheel position is achieved. In view of the fact that the control wheel on this machine is in a fixed position, the dial indicator for the control wheel sensing jet registers zero when the jet assembly is correctly adjusted back to the periphery of the control wheel. The dial indicator for the grinding wheel registers zero when the wheel head has advanced after truing to the grinding wheel head sensing jet.

Automatic truing is confined to the grinding wheel, which generally experiences much greater wear and requires more frequent truing than the control wheel. Therefore, when the control wheel has been trued in the normal manner, it is necessary to reset manually the position of the sensing jets between the wheels by means of the hand wheel adjustment to the lower slide. This is adjusted until the control wheel jet dial indicator registers a zero reading. For advancing the grinding wheel, following the control wheel truing operation, the operator will manually operate a push button, thereby advancing the wheelhead increments until the grinding wheel jet indicator also registers zero reading. This manual operation is only necessary after control wheel truing; under normal operation the

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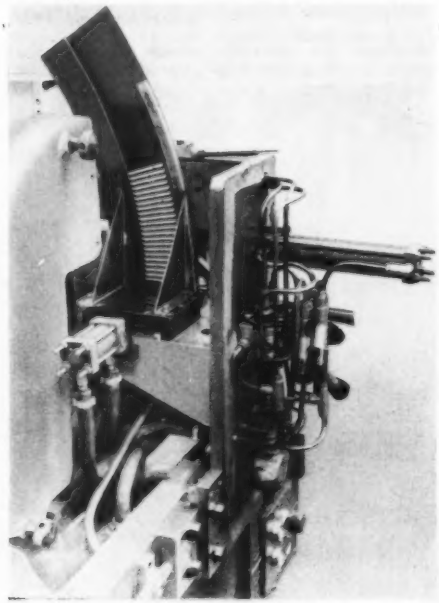


Fig 6 (Left). Synchronized loading attachment showing air operated cross slide and components in magazine.

Fig 7 (Right). Sigmatrol Major for automatic sizing and wheel dressing control.

"Storied Windows Richly Dight"

The uses of diamond grinding wheels are many, but they are mostly of a strictly utilitarian nature, and although finely finished machine parts have a beauty of their own, this is a by-product, and not an essential part of the process. There are a few cases, however, where the end-product is intentionally a thing of beauty and a work of art, and of these the stained glass windows being made by Mr. Ervin Bossanyi for Canterbury Cathedral are outstanding examples.

These windows have been commissioned to replace those destroyed during the war: some are already installed, and the rest will follow in the course of the next few months. The artist is a worker in the old tradition of stained glass; he is not merely a designer, but is a true artist-craftsman, who carries out all the processes of making the windows in his own studio, and has even worked in the glass manufacturies in order to improve his knowledge of his chosen medium. His windows are not just pictures that have been reproduced in coloured glass, but are designed from the start to make the best of the various and beautiful effects that can be produced by the proper use of stained glass in a suitable setting.

Problems of Strength

A stained glass window is not only a work of art, it is also a complex piece of engineering. The leaden mesh that holds the hundreds or thousands of pieces of glass together in the frame of the window must make up a structure strong enough to support its own weight—no small matter—and to resist all the forces of weather that may attack it. This means that every section of glass must be firmly held in the leading, and this is where much of the difficulty of the work is found. The glass used for windows of this sort is not, like ordinary window glass, all of one even thickness; to get his effects of depth and brilliance, his variations of tone and shading of colour, Bossanyi uses glasses of many different types, varying in thickness from something like a quarter of an inch, to the 'dall' that comes in blocks that are about two to two and a half inches thick. Material of this sort is used in fragments of various sizes to add depth to the tone of the thinner glasses, and presents a considerable problem in the mechanical construction of the window.

Mr. Bossanyi commences work by preparing a small sketch—at a scale of about one inch to the foot—in special black ink on Perspex sheets set in a board to represent a wall. These black lines represent the lines of leading and the framework of the window, and the colour is added by attaching small pieces of the actual glasses to be used in the full scale window to the reverse side of the Perspex. From this preliminary sketch, the full-sized working drawing is prepared, drawn in black ink on Ethulon sheet, and coloured with drawing inks. In this way, Mr. Bossanyi avoids the use of opaque materials that might give a misleading impression of the effect that will be produced in a translucent medium, and this is undoubtedly one of the reasons for the outstandingly successful results that he achieves.

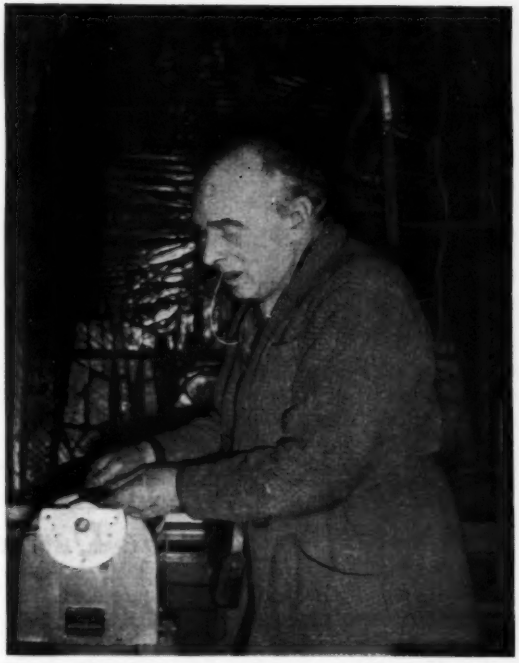


Fig 1. Ervin Bossanyi is here seen at work fining down the edge of a small piece of thick glass, to be used in the halo round the head of a Saint in one of his Canterbury Cathedral windows. The full scale working drawing is seen in the background.

From this full-scale working drawing, Mr. Bossanyi prepares paper patterns for each separate piece of glass, marking on the pattern the colour and type of glass to be used, and making allowance in the cutting for the thickness of the leading between the pieces. These paper patterns are then held on the sheet of glass, and a glazier's diamond is used to cut the outline.

This procedure, however, can only be applied to the thinner glasses ; the thicker ones, that are generally used in comparatively small pieces, are broken roughly to shape on a steel anvil, with a hammer and chisel, and then chipped and ground to their final form. This process includes the necessary reduction of the edges so that they will fit into the leading, and until recently, Mr. Bossanyi had to work labouriously by hand with abrasive sticks, a slow process that gave rise to a fairly high number of rejects.

The labour of this part of the work has been greatly reduced, and its speed and accuracy improved by the use of a Pencil Edging Machine (designed for glass-working of a more utilitarian nature) fitted with a bronze-bonded diamond wheel. This useful equipment, that has greatly lightened Mr. Bossanyi's labour, was presented to him, as a contribution towards the restoration of the Cathedral and as a tribute to him as an artist, by the manufacturers, Autoflow Engineering Ltd, of Birmingham, and Diagrit Ltd, of Marden, Kent.

When all the pieces have been formed to shape, they are assembled temporarily by being fixed to a large sheet of clear glass for the finishing touches to be given. The lines and shading to give the last details are printed on with the special pigments used, and the glass is fired in the furnace. Where several sheets of glass are to be used, one behind the other for special effects, they are fused together at this stage. After this, the final assembly in the frame with the leading is all that remains to be done before the window is fixed in position.

As well as the Canterbury Cathedral windows, examples of Ervin Bossanyi's work are to be found in the Victoria and Albert Museum, in the Goldsmiths' Hall, and the Tate Gallery in London, in Christ Church, Port Sunlight, in the School Chapel at Michael House, Balgowan, Natal, and in many other places both in and out of England.

Mobile Demonstration Van

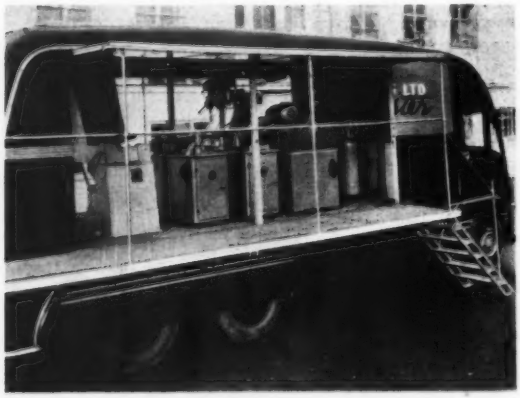
Impregnated Diamond Products Ltd, of Gloucester, have prepared a mobile demonstration, set up in a Foden lorry specially fitted out, that is to tour the country, and will be available to give demonstrations of the use and care of the Neven range of diamond tools to users and prospective users on the spot at their own factories.

The lorry, as can be seen from our illustration, is fully fitted with a representative range of machine tools for carrying out a number of operations, including the cutting and grinding of glass, ceramics, carbides, quartz and germanium crystals, and refractory materials.

This demonstration should prove extremely valuable to any firm wishing to undertake new techniques or to improve existing knowledge of such processes. We shall be pleased to pass on any requests from engineering firms who would like to have a visit from the demonstration van.

(*Adamant comments on this on page* 45)

The Foden demonstration lorry of Impregnated Diamond Products Ltd.



Throw-Away-Type Insert Package

A new plastic package is offered by Adamas Carbide Corporation of Kenilworth, NJ, for their throw-away insert bits.

Individually formed clear plastic pockets provide secure protection for the range of square, triangular, and round inserts, and permit quick inventory checks. The easy open slide portion of the package allows for one-at-a-time insert dispensing. One side of this pocket-size slide portion features a decimal equivalent chart and rule protected by a full 1/32 in. covering of clear plastic to ensure clean, clear readability through the hardest of use. Below this chart is a radius gauge for accurate spot checking of corner radii. The reverse side of the slide portion features a re-usable pencil note space with a unique silicate surface finish providing an always-handy and erasable surface for job notes and sketches.

New Reishauer Profiling Machine

A new and economical addition for gear grinding departments is the type AM truing and profiling machine. A product of Outils Reishauer Société Anonyme, Zurich, it is obtainable in this country from the sole UK distributors: Dowding & Doll Ltd, 346 Kensington High Street, London, W 14.

Introduction

The machine is intended principally for the finishing and re-profiling of pre-profiled grinding worms, but it can also be used for pre-profiling where a small pitch only is required. It has been developed to permit the re-profiling of wheels in shops employing a number of machines from which the integral dressing attachment is omitted, *eg* the Reishauer types ZB and OZA, thus effecting an economy. Its speed of operation permits 6 gear grinders to be constantly provided with grinding worms.

Operating procedure

The machine incorporates an automatic closed cycle of motions which comprises:

(i) working strokes, during which the diamond profiling tools travel from right to left, truing both flanks,

(ii) radial withdrawal of the profiling tools,

(iii) rapid return of profiling tools from left to right, and

(iv) radial infeed of the profiling tools.

During the operation, the independently adjustable truing heads guide the diamond tools, enabling pressure angles between 14° 30' and 30° to be obtained. Gauge blocks facilitate the setting of the pressure angles. With the universal diamond truing device, profiles can be obtained which allow the grinding of gears with standard or modified shapes. To form tip and root relief angles, truing diamonds with a slightly convex cutting edge are used. Such modifications call for corrections on the grinding worm profile, and in order to achieve this the truing diamonds are controlled by suitable templates and a simple linkage.

Pitch and wobbling errors

The most important factors affecting the performance of grinding worms are the errors induced by faulty pitch and wobbling, and in order to reduce these errors to a minimum the AM incorporates a special correcting mechanism.

Drive and control

The main motor is located within the base of the machine. It rotates slowly when profiling,

General view of the type AM truing and profiling machine.

a higher speed being available for dressing the outer diameter of the grinding worm. The motor drives the work spindle through a four-gear train. At the beginning of the return stroke of the truing slide, the work spindle, leadscrew, and drive, change their direction of rotation by means of hydraulically operated multi-plate clutches. The infeed of the radial slide, which carries the dressing slide, is similarly controlled. Stops are provided which permit the setting of the dressing slide.

Profiling tools

A variety of tools is available for attachment to the truing slide. These include a number of devices for root crushing, and tools for rounded crest profiling and other specialist operations.

Coolant system

A detachable oil tank is provided with the machine for the coolant system which is used during the crushing operation.

USP 2,792,824

United States Patent 2,792,824, granted to A. Rickenmann of Reishauer-Werkzeug AG, describes more fully a similar truing device. A summary of the patent appeared in *Industrial Diamond Abstracts* 1958 Vol 15 p A22 (Feb).

*Cutting and Grinding Ceramics**

R. F. Rea** and J. W. Ripple†

Introduction

A rapidly growing field is the precision grinding of fired ceramic products to very close tolerances. Due to dimensional changes in drying and firing, it is generally impossible to expect to hold tolerances closer than ± 1%. With modern grinding facilities and techniques very close finish tolerances on ceramics may be obtained, frequently ±0.0001 or better. Grinding also provides improved surface finishes, the quality of which depends on the abrasive used, the body being ground, and grinding practices. The selection of proper abrasive wheels and the more important factors contributing to successful results are discussed.

Fired ceramics

The cutting and grinding of fired ceramic materials is becoming increasingly important. This is true particularly in those areas where the mechanical properties—wear resistance and hardness—dictate its use. Such applications as gauges, dies, bearings, cutting tools, etc, require a degree of dimensional accuracy and surface finish that cannot be obtained except by grinding after firing. In other fields of technical ceramics, too, the requirements on dimensions or finish are becoming more stringent; especially where the ceramic is to be assembled with metal components as in the case of ceramic vacuum tube envelopes and ceramic-to-metal seals.

Fig 1. Precision-ground aluminium oxide cutting tools.

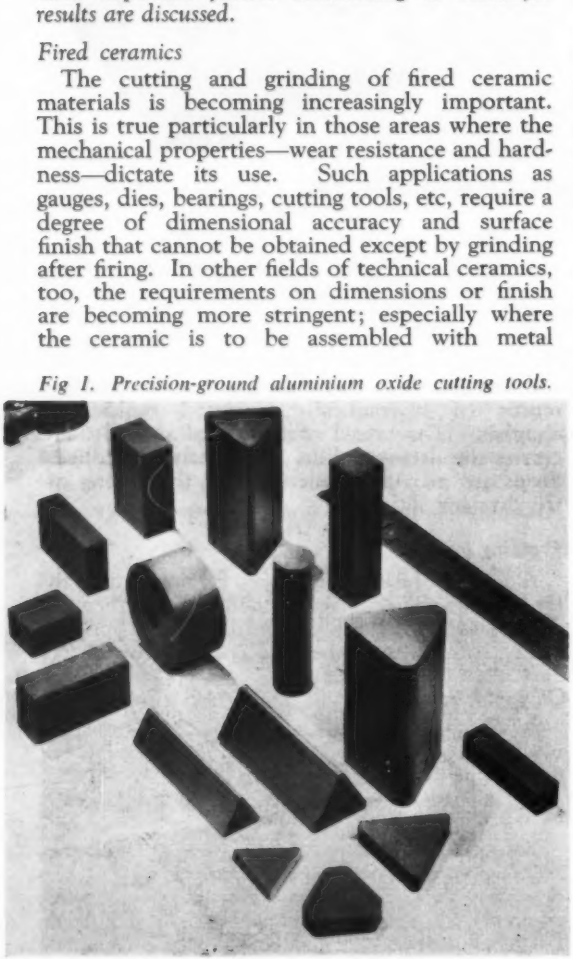


Fig 1 shows a group of aluminium oxide cutting tools which are precision ground on all faces. High alumina coil forms are shown in Fig 2. The threads on these coils are ground after firing. Fig 3 shows the dimensional specifications which these coils are required to meet.

Holding dimensional tolerances

In the manufacture of technical ceramics a tolerance of ± 1% or 0.005 inch, whichever is the greater, is commonly accepted as satisfactory. Where closer dimensional control is necessary, however, grinding must generally be resorted to. With modern machines and abrasive wheels, grinding even the hardest ceramics to ±0.0005 presents no problem and, with some experience and proper set up, tolerances of ±0.0002 or better can be met. Fig 4 shows a ceramic roller bearing made of a high alumina body, most of the dimensions of which are held to ±0.0001 and in some cases ±0.00004.

In holding such close tolerances, the equipment must be of high quality and must be maintained in the best condition. Jigs and fixtures must be properly designed and built with great precision. The experience and skill of the operator plays no little part in the success of the process. The inherent dimensional stability of ceramic materials permits as high a degree of precision as is possible with any material known and the accuracy being attained today is by no means the limit.

Surface finish

As mentioned in the introduction, the quality of the surface finish must frequently be much better than can be obtained on the fired ceramic. Several factors influence the quality of the surface that can be reached by grinding.

Porosity, even to a very minor degree, can prevent the attainment of a good finish. Ceramic bodies that are comprised of two or more phases of differing hardness, as for example, a hard crystalline phase and a softer glassy bond, also present a problem when a high finish is required. The relative size of the crystals is also a factor, and the best finish on polycrystalline

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* Reprinted with permission from the American Ceramic Society Bulletin (1957 Vol 36 (5) pp 163-167 (May)).

** Diamonite Products Mfg Co.
† Carborundum Co, Bonded Abrasives Div.

ceramic bodies is obtained when the size of these crystals is as fine as possible.

Of major importance in determining the quality of surface finish is the abrasive that is used, particularly the size of the abrasive grains. Some examples of the effect of grit size are given in Table I for three high alumina ceramics. All are fine grained and non-porous bodies. The quality of the finish improves progressively with increased alumina content. The 99% alumina body has a density of about 99% of the theoretical maximum for corundum and is extremely fine grained (around 1 or 2 microns). Hence the conditions approach an optimum for obtaining a good finish.

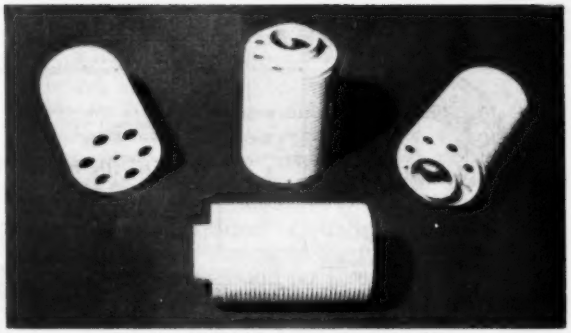


Fig 2. High-alumina ceramic coils.

Grinding media

For most purposes in grinding ceramic materials, abrasive wheels are used. Only for extra fine finishes or in lapping mating surfaces is the abrasive used in a liquid suspension.

The choice of abrasive for grinding fired ceramics is either silicon carbide or diamond. Other abrasive grains are rarely used. In cutting or grinding porcelain, steatite, cordierite, zircon and other moderately hard bodies, silicon carbide is often the choice and satisfactory results are obtained. In grinding harder ceramic materials, in particular those that are high in aluminium oxide, only diamond can be relied on to do an economical and satisfactory job. The same is true in grinding silicon carbide and other hard carbides.

It is generally recognized that for satisfactory grinding of ceramics, the abrasive should be harder than the workpiece, and the greater the difference, the more rapid the stock removal.

Hardness of abrasives

The term ' hardness ' is difficult to define and equally difficult to measure. The more familiar method of measuring hardness depends on the indentation of a small diamond pyramid into the material under test. For metals and other materials possessing any degree of ductility, this method is quite satisfactory. The Rockwell method depends on the depth of penetration, whereas the Knoop and Vickers methods depend on the measurement of the lateral dimensions of the impression. These methods have limited value in indicating the hardness of ceramic materials. Generally the ceramic fractures in such a way that the measurement of the impression made by the diamond indenter is inaccurate.

Table I. Effect of abrasive grain on finish of ceramics

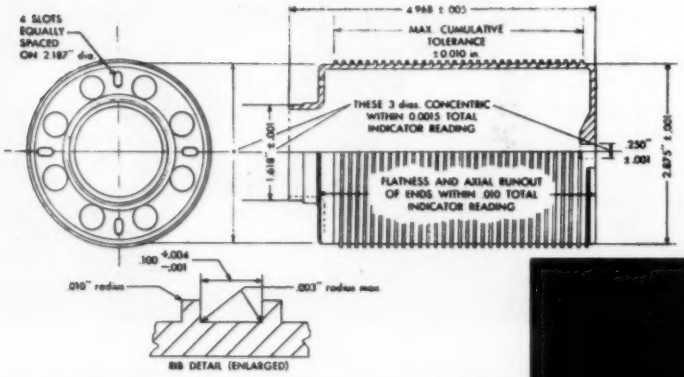
Body	*Diamond grit*	*Finish (micro-inch)*
83% Alumina	100	35-40
	320	20-25
	600	15-20
96% Alumina	100	25-30
	320	10-15
	600	7-10
99% Alumina	100	15-20
	220	9-13
	320	7-10
	2 micron	4-5

The Mohs' scale is familiar to most ceramists. It is the scale of the mineralogist, but its use has been extended to the field of artificial minerals. On the Mohs' scale, diamond is considered to have a value of 10, corundum (aluminium oxide) is 9, topaz is 8, quartz 7, feldspar 6 and so on down to talc, the softest mineral, with a value of 1. The scale is, however, not at all linear and this fact seriously limits its application. The non-linear character is particularly true in the range of 9 to 10, or between corundum and diamond. A number of artifical minerals have a hardness greater than corundum, but less than diamond. Among these are the carbides of silicon, boron and tungsten, and of several other metals.

Charles Wooddell[1] described a method which he used to evaluate the hardness of various abrasives which is most interesting and useful. He presents his data as two modified Mohs' scales, the first of which assumes a value of 10 for diamond and 9 for corundum and a second scale which assumes corundum to be 9 and quartz to be 7. Unlike Mohs', however, these scales are both linear.

Table II is from Wooddell's paper and shows a more exact picture of the relation between diamond, corundum and the artificial carbides with respect to hardness. Note particularly that the difference in hardness between diamond and corundum is more than six times as great

1) C. E. Wooddell—Method of comparing the hardness of electric-furnace products and natural abrasives—*Electrochem Soc Trans* 1935 Vol 68 pp 111-128.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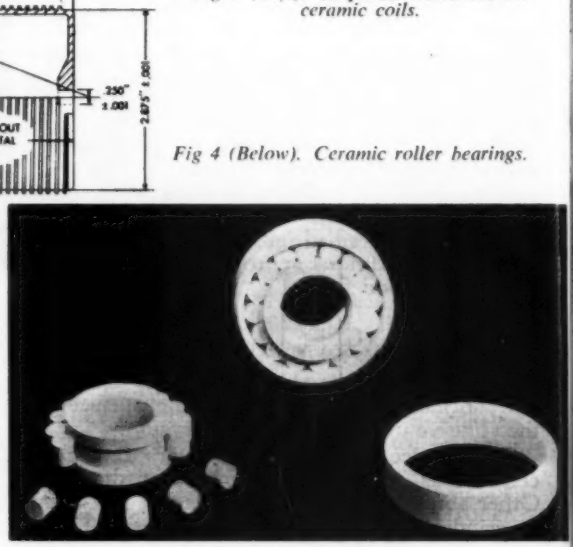
.100 +.004 −.001
.010" radius
.003" radius max
BB DETAIL (ENLARGED)

Fig 3 (Left). Required tolerances on ceramic coils.

Fig 4 (Below). Ceramic roller bearings.



as the difference between silicon carbide and corundum. Since the rate of cutting or grinding of an abrasive grain is more or less proportional to the difference in hardness of the material doing the cutting and the material being cut, it is obvious that diamond possesses a considerable advantage over silicon carbide, particularly when cutting a ceramic predominantly corundum, as is the case with the high alumina bodies.

Wheel bonds

A number of different bonds are used in forming abrasive grains into wheels. Only those types that are of interest in connexion with the present subject will be discussed.

In the case of silicon carbide, both vitrified and resinoid bonds are used. In grinding operations on ceramics, the former is generally preferred. The vitrified bond holds the grains more securely than other types and is suitable for heavy work. Vitrified wheels are limited to moderate surface speeds (not over 6,500 ft/min) and are not suitable for cut-off wheels. The resinoid bond is tougher and more resilient. Resinoid wheels may operate at higher speeds (up to 9,500 ft/min) and are recommended for thin wheels and for wheels that are subject to severe lateral pressure or shock.

Table II. Modified Mohs' Scale of Hardness (after Wooddell)

	Scale Diamond = 10 Corundum = 9	*Scale Corundum = 9 Quartz = 7*
S American boart	10.00	42.4
Belgian Congo clear white diamond	9.95	40.7
S American carbonado	9.82	36.4
Boron carbide	9.32	19.7
Black silicon carbide	9.15	14.0
Fused aluminium oxide	9.03	10.0
African crystal corundum	9.00	9.0
Rock crystal quartz	8.94	7.0

Diamond wheels are made with the same two bonds, but the preferred bond is metal. One consideration favours resinoid bonded diamond wheels. Metal bond has a harsh action which contributes to chipping of the edges of the work. Often this is of little importance. The material may be such that it does not chip readily or the use of the finished parts may be such that slight chipping is not objectionable. In cases where chipping of edges does become a problem, however, resinoid bonded wheels may be the answer. It is often possible to rough grind with a metal bonded diamond wheel and finish grind with a wheel having a resinoid bond. Normally, however, metal bonded diamond wheels will give much greater life than resinoid wheels.

Wheel designations

In selecting a wheel, the following factors, other than size, are to be considered: abrasive type, grit size, grade, concentration (in case of diamond), bond, and depth of diamond section.

Table III. Standard marking system for diamond wheels

(1) D	(2) 100	(3) J	(4) 100	(5) B	(6) ( )	(7) 1/8
Abrasive type	*Grit size*	*Grade*	*Concentration*	*Bond*	*Bond modification*	*Depth of diamond (inches)*
Diamond	30 to 1000	A-Softest to Z-Hardest	25 (low) 50 (med) 100 (high)	B-Resinoid M-Metal V-Vitrified		1/32 1/16 1/8 1/4

Table III shows the standard marking system for diamond wheels. The first symbol indicates the abrasive type, in this case diamond. The second is the grit size. The third symbol, the grade, refers to the hardness of the bond. The selection of the proper grade is important, since a bond that is too soft will result in excessive wear of the wheel, while one that is too hard is equally unsuitable. In the latter case, the abrasive grains will dull but will not break away from the bond. When this happens, grinding action slows down or stops and the wheel will require dressing. Experience is the best guide in selecting a wheel of the proper grade. In our own case, it has been found that diamond wheels in the grades from N to R are most satisfactory for grinding ceramics.

The concentration of diamonds is indicated by the fourth symbol. The most common concentration is 100 (not standardized, but in

Fig 5. Grinding ceramic plates.

the case of one leading wheel manufacturer equivalent to 72 carats of diamond per cubic inch). A concentration of 50 contains half as many diamonds per unit volume. A 50 concentration costs less and sometimes is used where short runs are made on special jobs. A concentration of 25 is also made but not often used. The fifth symbol is the bond. Sometimes a special bond modification is indicated as the next symbol. The final symbol, a fraction, indicates the depth of the diamond section. This varies from 1/32 to $\frac{1}{4}$ inch in standard wheels.

Grinding operations

Just about every type of grinding is performed on ceramics. These include: off hand grinding, surface grinding, Blanchard grinding, double disk grinding, internal grinding, cylindrical grinding, form grinding, thread grinding, centreless grinding, and cut-off.

Fig 5 shows the grinding of ceramic on a Blanchard grinder equipped with a diamond wheel. Fig 6 shows the grinding of steatite parts on a double disk grinder, also with diamond wheels. In Fig 7, a coil form of high alumina is being internally ground. Cylindrical grinding of a ceramic tube is shown in Fig 8. In Fig 9, the threads are being ground on a coil form. Fig 10 shows the centreless grinding of a high alumina rod. Fig 11 shows a cut-off operation on high alumina, using a diamond wheel.

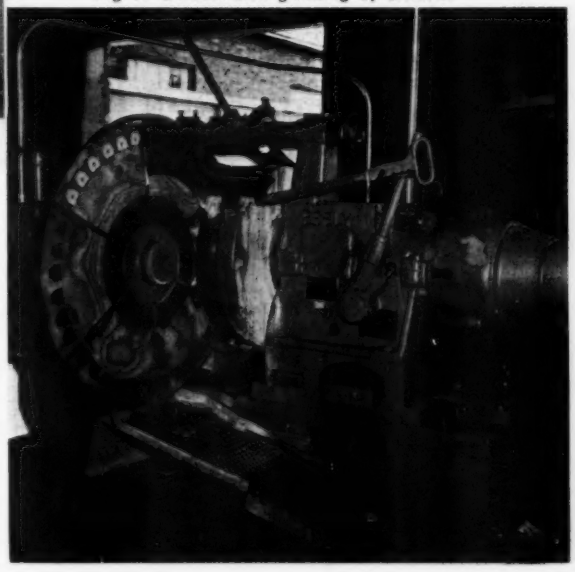
The set-ups and techniques for each class of grinding cannot be discussed within the scope of this paper, but certain general procedures are worthy of note.

Coolants

Coolants are always recommended for the protection of the workpiece and the wheel. Heat is generated in grinding and this can be harmful to the work, resulting sometimes in cracking due to heat shock and causing trouble in maintaining proper dimensions.

Coolant dissipates the heat and keeps the temperature down, protecting the wheel and increasing its life. Attention should be paid to the direction of the coolant as well as its volume. Location of the nozzle should be such that the wheel tends to pull the coolant into the cut.

Fig 6. Double-disk grinding of steatite.



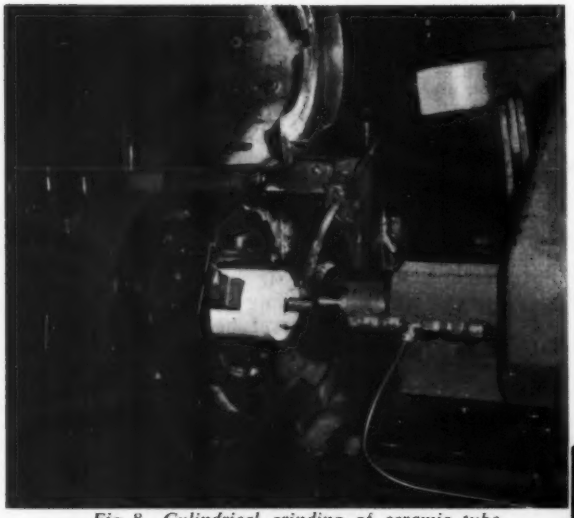


Fig 8. Cylindrical grinding of ceramic tube.

There is little use in supplying copious coolant if it is not directed where it is needed.

The type of coolant in the grinding of ceramics is open to wide choice. Almost every shop has its own pet coolant and all seem to be satisfactory. The general requirements of coolant are:

(1) Good heat transfer rate. From this standpoint alone, water is good.

(2) Protection of machine from rust. All commercial coolants have this quality.

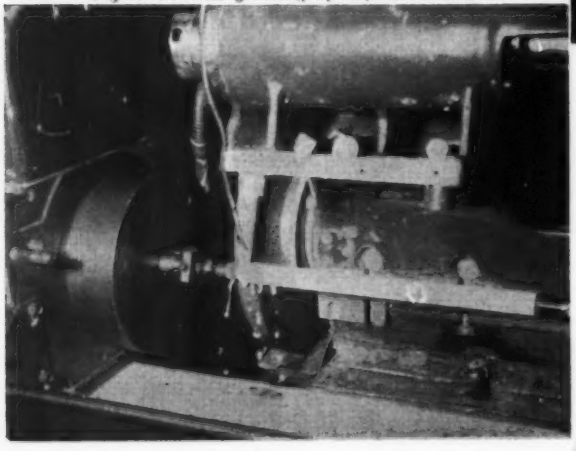
(3) Low alkalinity or neutral pH. Highly alkaline solutions attack resins and there are frequently resin cores even in metal bond diamond wheels. Cements used in wheel assembly are also frequently resins. Another feature is that highly alkaline coolants remove the paint from machines.

(4) Non-injurious to operators. Some coolants cause a dermatitis to some operators. This varies with coolants and individuals.

(5) Freedom from rancidity. This is a well-known caution and needs no elaboration.

(6) A detergent action is desirable. A slight detergency assists in keeping the wheel clean and free cutting. Strong detergency usually means high alkalinity.

Fig 7. Internal grinding of high-alumina coil.



Feeds and speeds

The optimum feeds and speeds are almost impossible to set down. Experience and trial-and-error are usually required. If a new material is to be ground and the grinding characteristics are not known, the usual and safest practice is to use low speeds and light feeds, gradually increasing each to obtain high production until it is seen that the maximum safe speed and feed has been reached.

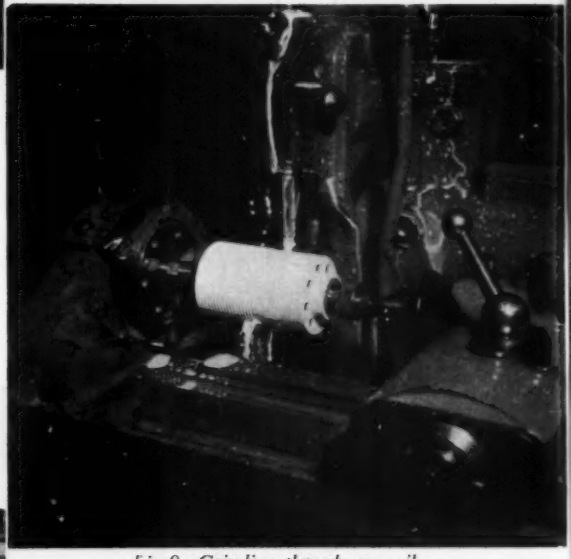


Fig 9. Grinding threads on coil.

Pushing a wheel beyond its ability to cut may result in the following objectionable conditions:

(1) Tearing the work loose from the chuck, or the threat of doing so.

(2) Excessive or large chipping.

(3) Inability to hold flatness, roundness or straightness, as the case may be.

(4) Overloading of the motor. The ammeter will reveal this.

(5) Wandering in the cut, in cut-off operations.

(6) Overheating, in spite of good coolant flow.
(7) Loosening or tearing off of the diamond section of the wheel.
(8) Bent, broken, warped or burned wheels.

Fig 10. Centreless grinding of alumina rod.

Fig 11. Cutting ceramic with diamond wheel.

The subject of finish was treated earlier. A few general comments regarding the technique of getting a good finish should be mentioned. Generally it may be said that better finishes are obtained with successively finer grained wheels. The cost of obtaining these finishes, however,

Concluded on page 59

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Endia Angle and Relief Truing Fixture

A new addition to the range of Endia wheel truing equipment is the Model ADS 920 angle and relief truing fixture, which is designed to be applied to cylindrical grinding machines for the purpose of truing angular faces for taper grinding, and also for relieving the sides of grinding wheels for grinding shouldered components.

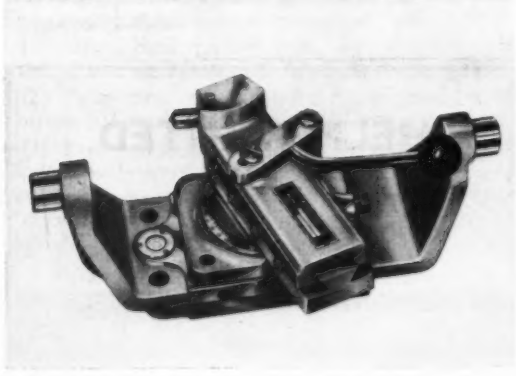
Specifications

The device has a precision dovetail slide, spigot-mounted to a rectangular base, which it is possible to set and lock at any angle by reference to the integral protractor. The slide is lever operated and has a stroke of two inches.

The front and rear edges of the rectangular base are ground square to the slide axis when set at the protractor zero, so that these edges can be used for a lignment on any support on the machine.

The base of the fixture is $3\frac{1}{2}$ x $4\frac{1}{2}$ in., the length of the dovetail slide is 6 in., and the height to the diamond axis is $2\frac{1}{8}$ in.

Fig 1. The complete unit ready for mounting.



Diamond stations

Two diamond stations are provided so that taper or relief truing of either side of the wheel can be carried out. These diamond stations are arranged in angular relation to the slide axis so that advantageous maintenance and maximum utilisation of diamond edges can be achieved.

Endia Model B 921

Available in addition to this dressing fixture, is Base Model B 921 (Fig 1) designed for applying the unit between centres of the machine. This base is fitted with a spirit level to facilitate the correct horizontal application on the wheel, and holes are provided to take $\frac{1}{2}$ in. diameter support bars which reach down to the machine table surface. The base is particularly useful when the device is to be used on several different machines.

When the truing fixture is supplied attached to base B 921, the unit has a height to diamond axis of $3\frac{1}{8}$ in., and an overall length of 12 in. Where it is to be allocated to one machine, an auxiliary base can be supplied for mounting the unit directly to the table of the machine.

Further details and descriptive literature are available from the manufacturers: Engineering Diamonds Limited, 26 Warwick Row, Coventry, England.

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The 1958 Gauge and Tool Exhibition, organised by the Gauge and Tool Makers' Association, will be held in the National Hall, Olympia, London, from May 12 to 21.

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The field covered at this exhibition is enormous, stretching into nearly every aspect of human activity, and producing examples of the most up-to-date equipment for almost every trade and industry, and for all the different branches of scientific research.

Fuller details can be obtained from the organizers, Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1.

International Exhibition at Brussels

On April 17 the King of the Belgians will open the great International Exhibition that is being staged in Brussels from April to October this year. Many countries are showing their products but the greater part of the Exhibition is being provided by Belgium and the Belgian colonies. This part of the display, in view of the large diamond output of the Belgian Congo, will include a special section devoted to diamonds and diamond mining, and will be officially opened on April 25. There will also be important sections in many of the national pavilions devoted to machine tools and scientific instruments, at which the latest developments will be shown.

BSA Centreless Grinder No. 4

Concluded from p 48

grinding wheel head will advance automatically during the grinding wheel truing cycle. Provision is also made so that the infeed motor and loading cycle will only re-start providing the measuring jets are in the correct position. This safeguards the possibility of an operator failing to reset the jets after truing the control wheel and the consequent production of over-size components.

Cutting and Grinding Ceramics

Concluded from p 57

mounts rapidly when a second or third grinding operation is added.

Every effort should be made to obtain the best possible finish with the roughing wheel and make this do. To accomplish this, the feeds and speeds are cut down when approaching the end of the grinding period. When size has been almost reached, a few more passes are taken at very low speed and very light or no infeed. While such an operation may appear to be slow and costly, it often produces results that are entirely satisfactory at worthwhile savings.

Insofar as it is possible to be specific in grading recommendations, we present below such a listing, with the warning that, as always, circumstances alter cases.

Roughing—Stock removal over 0.010 inch

SiC —GC60-H11-VR
Diamond—D100-N100-M (Metal, preferred)
D100-N100-BR (Resinoid, if necessary to eliminate chipping)

Finishing—Maximum stock removal 0.010 inch

Diamond—D220-N100-M (Metal, preferred)
D220-N100-BR (Resinoid, if necessary)

Super Finish—0.001 to 0.002 inch stock removal

Diamond—D400-N100-BR (Resinoid)
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